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10

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NPG REPORT NO. 1194

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Twelfth Partial Report
on
Development of a Cool Propellant
for the 5"/54 Caliber Gun

Final Report
on
Ballistic Test of Cool Propellants
EX-7084 to EX-7089 inclusive

Project No.: NPG-Re2d-61-1-53
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Date:

DEC 4 1953

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Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusivePART ASYNOPSIS

1. From the results of the subject tests, it is concluded that:

a. EX-7085 was ballistically satisfactory for use in the 5"/54 caliber gun with the 60 lb. projectile at a velocity of 3000 f/s.

b. EX-7088 was ballistically satisfactory at a velocity of 3000 f/s at a PPD (Production Packing Depth) of 3#1 but unsatisfactory at the proposed PPD of 3#5.

c. Satisfactory ballistics were obtained at 3000 f/s velocity at a PPD of 2#5 for EX-7085, EX-7087, and EX-7088.

d. The pressure-time curves obtained with the subject propellants had pronounced steps occurring in the pressure-rise region and were inferior to those obtained with either EX-6822 or EX-6883.

2. From the results of the subject tests, the following recommendations for a powder granulation, as requested in reference (b), are as follows:

<u>Velocity</u> <u>(f/s)</u>	<u>Pressure</u> <u>(t.s.i.)</u>	<u>Approx.</u> <u>PPD</u>	<u>Flame Temp.</u> <u>°K</u>	<u>Av. Web</u> <u>(in.)</u>	<u>L/D</u>
3000 (a)	22-24	3#5	2200	0.0410	2.3
3000 (b)	22-24	3#1	2250	0.0430	2.3

(a) Similar to EX-7085

(b) Similar to EX-7088

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

TABLE OF CONTENTS

	<u>Page</u>
SYNOPSIS.	1
TABLE OF CONTENTS	2
AUTHORITY	3
REFERENCES.	3
BACKGROUND.	3
OBJECT OF TEST.	4
PERIOD OF TEST.	4
DESCRIPTION OF ITEMS UNDER TEST	4
PROCEDURE	5
RESULTS AND DISCUSSION.	5
CONCLUSIONS	8
RECOMMENDATIONS	9
APPENDIX A - TABULATION OF FIRING DATA.	1-13 (Incl)
APPENDIX B - GRAPHICAL REPRESENTATION OF FIRING DATA.	1-6 (Incl)
APPENDIX C - PRESSURE-TIME CURVES	1-4 (Incl)
APPENDIX D - DISTRIBUTION	1-5 (Incl)

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

PART B

INTRODUCTION

1. AUTHORITY:

The tests conducted herein were authorized by reference (b) under Task Assignment NPG-Re2d-61-1-53 as established by reference (a).

2. REFERENCES:

- a. BUORD Conf ltr NP9 Re2d-CNB:aph Ser 42692 of 29 July 1952
- b. BUORD Conf ltr Re2d-CNB:dad NP9 Ser 55117 of 13 Apr 1953
- c. BUORD Conf ltr Re2d-CNB:jd NOrd 9691 Ser 55201 of 14 Apr 1953 to E. I. du Pont Co., Inc.
- d. NPG Conf Report No. 984 of 18 Aug 1952
- e. BUORD Conf ltr Re2d-CNB:dad S78-1(54) Ser 59809 of 10 July 1953
- f. Description Sheets of Manufacture and Closed Bomb Data

3. BACKGROUND:

Reference (a) set up the general task for development of a cool propellant for the 5"/54 caliber gun. Reference (b) requested EX-7084 through EX-7089 be fired for ballistic assessment in the 5"/54 caliber gun, Mk 18 with the 60 lb. projectile in the 22-24 tsi pressure range at a velocity of 3000 f/s. Reference (b) described these propellants as cool picrite powders with nominal flame temperatures around 2180 to 2250 °K prepared in accordance with reference (c). Reference (b) further requested the Naval Proving Ground to recommend an optimum granulation (based on the results of the subject powders) for manufacture of a large lot of cool picrite powder for the continuation of erosion trials in the 5"/54 caliber gun presently being fired with EX-6883, as reported in reference (d). Reference (e) stated that the near-term objective in the 5"/54 caliber gun with the 60 lb. projectile is now being reduced from the original goal of velocities in the 3000 - 3100 f/s range to 2800 f/s because of projectile band failure at the higher velocities.

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

4. OBJECT OF TEST:

a. To determine whether the subject propellants are ballistically satisfactory in the 5"/54 caliber gun, Mk 18, at 3000 f/s velocity in the 22-24 tsi pressure range with the 60 lb. projectile.

b. To obtain data incident to the manufacture of a large lot of cool picrite powder for continuation of erosion trials in the 5"/54 caliber gun.

5. PERIOD OF TEST:

a. Dates Project Letters:	29 Jul 1953
	13 Apr 1953
b. Date Material Received:	8 Apr 1953
c. Date Commenced Test:	22 Apr 1953
d. Date Test Completed:	26 May 1953

PART CDETAILS OF TEST

6. DESCRIPTION OF ITEMS UNDER TEST:

Reference (f) described the subject propellants as follows:

a. Chemical Composition:

	<u>EX-7084</u>	<u>EX-7085</u>	<u>EX-7086</u>
Nitrocellulose (13.20%N)	19.84%	20.09%	19.41%
Nitroglycerin #3	11.88	11.99	11.95
Picrite	60.01	59.77	60.13
Centralite	1.96	1.91	1.89
Dibutylphthalate	6.31	6.24	6.62
Lead Carbonate (added)	0.97	0.95	0.92
Flame Temp. (°K)	2211	2202	2169

	<u>EX-7087</u>	<u>EX-7088</u>	<u>EX-7089</u>
Nitrocellulose (12.20%N)	20.30%	20.62%	20.45%
Nitroglycerin	13.86	12.47	12.30
Picrite	58.17	59.03	58.22
Centralite	1.85	1.90	1.77
Dibutylphthalate	5.82	5.98	5.82
Lead Carbonate (added)	0.93	0.93	0.94
Flame Temp. (°K)	2321	2244	2260

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

b. Grain Geometry and Closed Bomb Data:

<u>Sample</u>	<u>Length (in)</u>	<u>Diameter (in)</u>	<u>Av. Web (in)</u>	<u>No. of Perfs.</u>	<u>RQ (%)</u>	<u>RF (%)</u>
EX-7084	0.5193	0.2157	0.0369	7	107.8(a) 96.8(b) 119.1(c)	105.3(a) 93.0(b) 95.5(c)
EX-7085	0.5258	0.2301	0.0405	7	98.2(a) 88.2(b) 108.5(c)	104.5(a) 92.3(b) 94.8(c)
EX-7086	0.5479	0.2420	0.0424	7	86.7(a) 77.8(b) 95.7(c)	104.2(a) 92.0(b) 94.5(c)
EX-7087	0.5267	0.2303	0.0404	7	113.3(a) 99.9(b) 123.0(c)	110.3(a) 96.5(b) 99.8(c)
EX-7088	0.5514	0.2428	0.0433	7	98.1(a) 86.6(b) 106.6(c)	107.5(a) 94.0(b) 97.3(c)
EX-7089	0.5809	0.2542	0.0462	7	95.0(a) 83.8(b) 103.3(c)	107.2(a) 93.8(b) 97.1(c)

(a) Based on EX-6586 as 100% at 90°F

(b) Based on EX-6883 as 100% at 90°F

(c) Based on EX-7001 as 100% at 90°F

7. PROCEDURE:

The subject propellants were fired in the 5"/54 caliber gun Mk 18-0 for charge determination. Muzzle velocities, maximum pressures (copper crusher), and ejection times were recorded. Pressure time records on the subject powders were obtained in both the Mk 16-0, and Mk 18-0 gun. All charges were assembled at PPD (Production Packing Depth).

8. RESULTS AND DISCUSSION:

The results of the subject tests are given in detail in the Appendices and are summarized below:

CONFIDENTIAL
SECURITY INFORMATION

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

a. Uniformity:

Date 1953	Powder	PPD (in)	Charge (lb)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (millisec)	No. of Rounds
4-22	EX-7084	10.5	16.00	2539±2	16.6±0.1	18±0	2
"	"	5.7	19.50	2877±3	23.5±0.5	16±1	5
"	EX-7085	8.1	18.00	2673±5	17.0±0.1	18±2	2
"	"	3.3	21.60	3000±4	23.6±0.6	16±1	5
"	EX-7086	6.7	19.00	2649±4	15.3±0.1	19±2	2
"	"	1.4	22.90	2992±5	21.1±0.5	16±1	5
4-23	EX-7087	9.1	17.00	2711±2	18.8±0.4	18±2	2
"	"	6.3	19.00	2901±3	22.7±0.2	16±1	5
"	EX-7088	7.9	18.00	2668±7	16.4±0.2	19±1	2
"	"	3.8	21.00	2937±4	20.7±0.5	17±1	5
"	EX-7089	6.6	19.00	2706±1	15.4±0.1	20±1	2
"	"	2.0	22.30	3001±4	21.0±0.5	16±1	5
4-29	EX-7084	5.6	19.50	2876±5	24.4±0.2	18±1	2
"	EX-7085	3.2	21.60	2993±8	25.2±0.2	19±2	2
"	EX-7086	1.2	22.99	2990±7	23.1±1.4	19±2	2
"	EX-7087	5.7	19.30	2908±2	25.1±0.1	18±2	2
"	EX-7088	2.7	21.70	2996±11	24.0±0.5	20±0	2
"	EX-7089	1.9	22.29	2977±1	21.0±0.3	21±0	2
5-12	EX-6883	7.3	18.50	2827±3	18.0±0.1	19(a)	2
"	"	4.8	20.28	2994±1	20.9±0.2	20±1	5
"	"(b)	4.8	20.28	2997±3	21.2±0.1	19±1	5
"	EX-7085	7.3	18.50	2719±2	18.2±0.1	17±0	2
"	"	3.1	21.60	2995±2	23.7±0.5	17±1	5
"	EX-7086	6.5	19.00	2649±2	15.4±0.1	19±1	2
"	"	1.1	22.99	3004±5	22.2±0.5	17±1	5
5-15	EX-7087	8.9	17.00	2708±3	19.6±0.4	20±1	2
"	"	4.6	20.04	2994±3	25.2±0.3	17±1	5
"	EX-7088	7.7	18.00	2669±1	16.6±0.0	18±0	2
"	"	2.6	21.70	3006±9	22.8±0.6	17±1	5
"	EX-7089	6.4	19.00	2697±5	15.5±0.6	19±0	2
"	"	1.8	22.29	2997±7	21.5±0.3	17±0	5
5-21	EX-7085	2.5	21.70	2989±5	22.5±0.1	19±0	3
"	"	4.1	20.50	2881±2	20.5±0.1	18±2	2
"	EX-7088	2.5	21.60	2991±8	22.3±1.0	18±2	3
"	"	7.5	18.00	2664±1	16.2±0.1	18±0	2
"	EX-7087	2.5	20.10	2986±4	22.6±0.5	17±1	3
"	"	6.4	17.50	2732±3	18.2±0.1	18±0	2
"	EX-7084	2.5	20.80	2979±10	24.2±1.1	18±2	4
"	"	6.6	18.00	2726±5	18.8±0.5	18±0	2
5-26	EX-7084	2.5	21.03	3005±6	25.3±0.4	16±1	2
"	EX-7087	2.5	20.24	2991±4	23.1±0.2	17±2	2
"	EX-6822	2.5	20.60	2998±1	20.8±0.2	19±0	2
"	EX-6882	2.5	20.42	2996±5	20.6±0.2	19±0	2

(a) Based on 1 round

(b) XC-M5B primer

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

b. Charge determination:

Gun: 5"/54 caliber, Mk 18 Mod 0, No. 16077

<u>Powder</u>	<u>Charge (lb)</u>	<u>PPD (in)</u>	<u>Velocity (f/s)</u>	<u>Pressure (t.s.i.)</u>	<u>Results</u>
EX-7084	20.77	4.2	3000	26.0	Too quick
EX-7084	21.03	2.5	3000	24.6	Too quick
EX-7085	21.60	3.5	3000	23.6	
EX-7085	<u>21.66</u>	<u>3.5</u>	<u>3000</u>	<u>23.9</u>	
EX-7085(a)	21.63	3.5	3000	23.8	Satisfactory
EX-7085	21.82	2.5	3000	22.7	Satisfactory
EX-7086	22.99	1.5	3000	21.3	
EX-7086	<u>22.94</u>	<u>1.5</u>	<u>3000</u>	<u>22.1</u>	
EX-7086(a)	22.97	1.5	3000	21.7	Too slow
EX-7087	20.04	5.0	3000	24.7	
EX-7087	<u>20.10</u>	<u>4.9</u>	<u>3000</u>	<u>25.3</u>	
EX-7087(a)	20.07	5.0	3000	25.0	Too quick
EX-7087	20.24	2.5	3000	22.8	Satisfactory
EX-7088	21.70	3.0	3000	23.3	
EX-7088	<u>21.63</u>	<u>3.1</u>	<u>3000</u>	<u>22.7</u>	
EX-7088(a)	21.67	3.1	3000	23.0	(b)
EX-7088	21.70	2.5	3000	22.4	Satisfactory
EX-7089	22.29	2.2	3000	21.0	
EX-7089	<u>22.32</u>	<u>2.2</u>	<u>3000</u>	<u>21.6</u>	
EX-7089(a)	22.31	2.2	3000	21.3	Too slow
EX-6883	20.34	2.5	3000	21.0	(c)

(a) Average of 2 gun firings

(b) Ballistically satisfactory at PPD (Production Packing Depth) of 3#1 but unsatisfactory at proposed 3#5 PPD.

(c) Reported in reference (d).

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

c. EX-7085 was satisfactory ballistically in that a velocity of 3000 f/s was obtained within the prescribed pressure range of 22-24 tsi and proposed PPD of 3#5.

EX-7088 was ballistically satisfactory at a PPD of 3#1 but unsatisfactory at the 3#5 level.

EX-7084 and EX-7087 were too quick for the 5"/54 caliber gun under standard powder packing conditions.

EX-7086 and EX-7089 were too slow for the 5"/54 caliber gun at 3000 f/s velocity in that only 21.7 and 21.3 tsi pressure was obtained at 1#5 and 2#2 PPD respectively.

d. EX-7084, EX-7085, EX-7087, and EX-7088 were fired for ballistic assessment at 3000 f/s with loose packing of 2#5. All of the propellants tested gave satisfactory ballistics and uniformities except EX-7084 which was too fast.

e. The pressure-time curves obtained with the subject powders had pronounced steps occurring in the pressure rise region and were inferior to those obtained with either EX-6822 or EX-6883.

PART D

CONCLUSIONS

9. From the results of the subject tests, it is concluded that:

a. EX-7085 was ballistically satisfactory for use in the 5"/54 caliber gun with the 60 lb. projectile at a velocity of 3000 f/s.

b. EX-7088 was ballistically satisfactory at a velocity of 3000 f/s at a PPD of 3#1 but unsatisfactory at the proposed PPD of 3#5.

c. Satisfactory ballistics were obtained at 3000 f/s velocity at a PPD of 2#5 for EX-7085, EX-7087, and EX-7088.

d. The pressure-time curves obtained with the subject propellants had pronounced steps occurring in the pressure-rise region and were inferior to those obtained with either EX-6822 or EX-6883.

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

PART E

RECOMMENDATIONS

10. From the results of the subject tests, the following recommendations for a powder granulation as requested in reference (b) are as follows:

<u>Velocity</u> <u>(f/s)</u>	<u>Pressure</u> <u>(t.s.i.)</u>	<u>Approx.</u> <u>PPD</u>	<u>Flame Temp.</u> <u>°K</u>	<u>Av. Web</u> <u>(in)</u>	<u>L/D</u>
3000(a)	22-24	3#5	2200	0.0410	2.3
3000(b)	22-24	3#1	2250	0.0430	2.3

(a) Similar to EX-7085

(b) Similar to EX-7088

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

The tests upon which this report is based were conducted by:

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NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

TABULATION OF FIRING DATA

Gun: 5"/54 Caliber,
Mk 18-0, No. 16077 ESR = 214.5 D₀ = 5.009
Mk 16-0, No. 15453 ESR = 114.8 D₀ = 5.018

Projectile: Mk 41-0 (60.00 lb) Empty

Cartridge Case: Mk 7-0 (NGF) Brass

Primer: Mk 45

Lead Foil: None

Plug: Cork

Wad and Spacer: Cardboard, NGF Dwg. No. 132664 Pc. Nos. 18 and 15

Powder Temp: 90°F

Note: Velocity and pressure corrected for variation of projectile weight to 60.00 lb nominal

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 22 April 1953 (Continued)

<u>Rd. No.</u>	<u>Powder</u>	<u>PPD (in.)</u>	<u>Charge (lbs.)</u>	<u>Velocity (f/s)</u>	<u>Pressure (t.s.i.)</u>	<u>Ejec. Time (millisec)</u>	<u>Flash (%)</u>	<u>Smoke (%)</u>
20	EX-7085	2.8	22.00	3058	25.7	14	25	125
21	EX-7086	6.7	19.00	2652	15.3	17	0	150
22	"	"	"	2645	15.2	20	"	"
	Mean of 2 rounds		19.00	2649±4	15.3±0.1	18±2		
23	EX-7086	3.3	21.50	2865	18.5	18	0	150
24	"	1.4	22.90	3003	21.9	17	100	100
25	"	"	"	2994	21.2	"	"	"
26	"	"	"	2992	21.3	18	75	125
27	"	"	"	2983	20.2	14	"	"
28	"	"	"	2987	20.7	15	Tr	150
	Mean of 5 rounds		22.90	2992±5	21.1±0.5	16±1		
29	EX-7087	10.5	16.00	2608	16.6	17	0	150
30	"	9.1	17.00	2711	18.9	19	"	"
31	"	7.0	18.50	2863	22.6	14	Tr	"
32	EX-7088	9.3	17.00	2575	14.5	26	0	"
33	"	7.9	18.00	2667	15.8	28	0	"
34	"	5.9	19.50	2809	18.3	-	"	"
35	EX-7089	6.6	19.00	2714	15.8	-	"	"
36	"	3.8	21.00	2889	18.7	16	"	"

(a) Conditioning round - not used

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SECURITY INFORMATION

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 23 April 1953

Gun: Mk 18-0, No. 16077

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (millisec)	Flash (%)	Smoke (%)
1 (a)	EX-7087	9.1	17.00	2705	18.4	16	0	150
2	"	"	"	2712	18.4	"	"	"
3	"	"	"	2709	19.2	19	"	"
Mean of 2 rounds			17.00	2711±2	18.8±0.4	18±2		
4	EX-7087	7.0	18.50	2861	22.5	18	0	150
5	"	6.3	19.00	2904	22.7	15	"	"
6	"	"	"	2902	22.9	16	"	"
7	"	"	"	2901	22.5	17	"	"
8	"	"	"	2892	22.5	18	"	"
9	"	"	"	2905	23.0	15	"	"
Mean of 5 rounds			19.00	2901±3	22.7±0.2	16±1		
10	EX-7087	5.8	19.30	2918	22.7	15	0	150
11	EX-7088	7.9	18.00	2674	16.5	18	"	"
12	"	"	"	2661	16.2	19	"	"
Mean of 2 rounds			18.00	2668±7	16.4±0.2	19±1		
13	EX-7088	5.9	19.50	2797	18.1	17	0	150
14	"	3.8	21.00	2930	19.9	19	"	"
15	"	"	"	2942	21.1	17	"	"
16	"	"	"	2936	20.3	"	"	"
17	"	"	"	2934	20.7	15	"	"
18	"	"	"	2942	21.7	17	"	"
Mean of 5 rounds			21.00	2937±4	20.7±0.5	17±1		

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SECURITY INFORMATION

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 23 April 1953 (Continued)

<u>Rd. No.</u>	<u>Powder</u>	<u>PPD (in.)</u>	<u>Charge (lbs.)</u>	<u>Velocity (f/s)</u>	<u>Pressure (t.s.i.)</u>	<u>Ejec. Time (millisec)</u>	<u>Flash (%)</u>	<u>Smoke (%)</u>
19	EX-7088	3.0	21.60	3008	23.3	17	100	100
20	EX-7089	6.6	19.00	2705	15.4	19	"	"
21	"	"	"	2706	15.4	20	0	150
	Mean of 2 rounds		19.00	2706±1	15.4±0.1	20±1		
22	EX-7089	3.8	21.00	2881	17.9	19	0	150
23	"	2.0	22.30	3002	21.1	15	"	"
24	"	"	"	2999	21.4	"	Tr	"
25	"	"	"	3005	20.6	18	"	"
26	"	"	"	3006	21.8	16	"	"
27	"	"	"	2991	20.3	17	0	"
	Mean of 5 rounds		22.30	3001±4	21.0±0.5	16±1		
28	EX-7089	1.5	23.00	3061	22.9	16	100	100

(a) Conditioning round - not used

CONFIDENTIAL
SECURITY INFORMATION

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 29 April 1953

Gun: Mk 16-0, No. 15453

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (millisec)	Flash (%)	Smoke (%)
1 - 10	REPORTED SEPARATELY							
11	EX-7084	5.6	19.50	2871	24.2	17	0	125
12	"	"	"	2881	24.6	19	"	"
	Mean of 2 rounds		19.50	2876±5	24.4±0.2	18±1		
13	EX-7085	3.2	21.60	3000	25.3	17	Tr	125
14	"	"	"	2985	25.0	20	100	100
	Mean of 2 rounds		21.60	2993±8	25.2±0.2	19±2		
15	EX-7086	1.2	22.99	2997	24.5	17	75	100
16	"	"	"	2983	21.7	21	"	"
	Mean of 2 rounds		22.99	2990±7	23.1±1.4	19±2		
17	EX-7087	5.7	19.30	2906	25.0	19	75	100
18	"	"	"	2909	25.2	16	"	"
	Mean of 2 rounds		19.30	2908±2	25.1±0.1	18±2		
19	EX-7088	2.7	21.70	3007	24.4	20	75	100
20	"	"	"	2985	23.5	"	"	"
	Mean of 2 rounds		21.70	2996±11	24.0±0.5	20±0		
21	EX-7089	1.9	22.29	2976	21.3	21	75	100
22	"	"	"	2978	20.7	"	100	"
	Mean of 2 rounds		22.29	2977±1	21.0±0.3	21±0		

CONFIDENTIAL
SECURITY INFORMATION

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 12 May 1953

Gun: Mk 18-0, No. 16077

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (millisec)	Flash (%)	Smoke (%)
1 (a)	EX-6883	7.3	18.50	2814	17.4	21	50	125
2	"	"	"	2824	17.9	-	0	"
3	"	"	"	2820	18.1	19	"	"
Mean of 2 rounds			18.50	2827±3	18.0±0.1	19 (b)		
4	EX-6883	4.8	20.28	2992	20.8	19	80	125
5	"	"	"	2995	21.4	20	50	"
6	"	"	"	2995	20.7	21	80	"
7	"	"	"	2995	20.9	19	0	"
8	"	"	"	2994	20.9	"	80	"
Mean of 5 rounds			20.28	2994±1	20.9±0.2	20±1		
9 (c)	EX-6883	4.8	20.28	2997	21.2	19	80	125
10 (c)	"	"	"	2995	21.2	"	"	"
11 (c)	"	"	"	3004	21.3	"	"	"
12 (c)	"	"	"	2997	20.9	21	"	"
13 (c)	"	"	"	2992	21.2	18	"	"
Mean of 5 rounds			20.28	2997±3	21.2±0.1	19±1		
14	EX-6883	3.4	21.31	3089	22.6	18	80	125
15	EX-7085	7.3	18.50	2717	18.3	17	0	"
16	"	"	"	2720	18.1	"	"	"
Mean of 2 rounds			18.50	2719±2	18.2±0.1	17±0		

CONFIDENTIAL
SECURITY INFORMATION

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 12 May 1953 (Continued)

<u>Rd. No.</u>	<u>Powder</u>	<u>PPD (in.)</u>	<u>Charge (lbs.)</u>	<u>Velocity (f/s)</u>	<u>Pressure (t.s.i.)</u>	<u>Ejec. Time (millisec)</u>	<u>Flash (%)</u>	<u>Smoke (%)</u>
17	EX-7085	3.1	21.60	2994	23.1	16	50	125
18	"	"	"	2991	23.1	19	"	"
19	"	"	"	2977	24.4	16	Tr	"
20	"	"	"	2998	23.7	17	50	"
21	"	"	"	2996	24.3	16	0	"
Mean of 5 rounds			21.60	2995±2	23.7±0.5	17±1		
22	EX-7085	2.6	22.00	3026	25.1	-	Tr	125
23	EX-7086	6.5	19.00	2647	15.3	19	0	"
24	"	"	"	2651	15.4	18	"	"
Mean of 2 rounds			19.00	2649±2	15.4±0.1	19±1		
25	EX-7086	1.1	22.99	2994	21.6	18	50	125
26	"	"	"	3006	22.2	17	"	"
27	"	"	"	3006	22.5	16	0	"
28	"	"	"	3012	23.0	19	Tr	"
29	"	"	"	3001	21.6	17	50	"
Mean of 5 rounds			22.99	3004±5	22.2±0.5	17±1		
30	EX-7086	0.6	23.40	3039	23.5	19	50	125

- (a) Conditioning round - not used
 (b) Based on one round
 (c) XC-M5B Primer

CONFIDENTIAL
SECURITY INFORMATION

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 15 May 1953

Gun: Mk 18-O, No. 16077

<u>Rd. No.</u>	<u>Powder</u>	<u>PPD (in.)</u>	<u>Charge (lbs.)</u>	<u>Velocity (f/s)</u>	<u>Pressure (t.s.i.)</u>	<u>Ejec. Time (millisec)</u>	<u>Flash (%)</u>	<u>Smoke (%)</u>
1 (a)	EX-7087	8.9	17.00	2706	19.0	19	0	150
2	"	"	"	2705	19.2	"	"	"
3	"	"	"	2710	19.9	20	"	"
Mean of 2 rounds			17.00	2708±3	19.6±0.4	20±1		
4	EX-7087	4.6	20.04	2996	25.6	19	Tr	150
5	"	"	"	2995	25.0	18	25	125
6	"	"	"	2988	25.1	15	Tr	150
7	"	"	"	2997	25.5	18	"	"
8	"	"	"	2992	24.6	16	"	"
Mean of 5 rounds			20.04	2994±3	25.2±0.3	17±1		
9	EX-7087	4.4	20.14	3005	25.1	16	Tr	150
10	EX-7088	7.7	18.00	2668	16.6	18	0	"
11	"	"	"	2670	16.6	"	"	"
Mean of 2 rounds			18.00	2669±1	16.6±0.0	18±0		
12	EX-7088	2.6	21.70	2995	22.3	16	Tr	150
13	"	"	"	3014	23.3	19	0	"
14	"	"	"	3009	23.1	16	Tr	"
15	"	"	"	3016	23.4	"	"	"
16	"	"	"	2995	21.8	18	25	125
Mean of 5 rounds			21.70	3006±9	22.8±0.6	17±1		
17	EX-7088	2.1	22.10	3029	22.8	16	Tr	150
18	EX-7089	6.4	19.00	2702	16.0	19	0	"
19	"	"	"	2692	14.9	"	"	"
Mean of 2 rounds			19.00	2697±5	15.5±0.6	19±0		

CONFIDENTIAL
SECURITY INFORMATION

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 15 May 1953 (Continued)

<u>Rd. No.</u>	<u>Powder</u>	<u>PPD (in.)</u>	<u>Charge (lbs.)</u>	<u>Velocity (f/s)</u>	<u>Pressure (t.s.i.)</u>	<u>Ejec. Time (millisec)</u>	<u>Flash (%)</u>	<u>Smoke (%)</u>
20	EX-7089	1.8	22.29	2997	21.6	17	100	100
21	"	"	"	3002	21.5	"	80	"
22	"	"	"	3011	22.0	"	"	"
23	"	"	"	2994	21.1	"	50	125
24	"	"	"	2983	21.1	19	0	150
Mean of 5 rounds			22.29	2997±7	21.5±0.3	17±0		
25	EX-7089	1.3	22.70	3020	21.8	18	20	150

(a) Conditioning round - not used

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 21 May 1953		Gun: Mk 18-0, No. 16077						
Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (millisec)	Flash (%)	Smoke (%)
1	EX-7085	6.9	18.50	2687	16.8	22	0	150
2	"	4.1	20.50	2882	20.5	19	"	"
3	"	2.5	21.70	2996	22.6	18	10	"
4	"	"	"	2984	22.3	19	0	"
5	"	"	"	2987	22.5	"	"	"
Mean of 2 rounds			21.70	2989±5	22.5±0.1	19±0		
6	EX-7085	4.1	20.50	2879	20.4	16	0	150
Mean of rounds 2 and 6			20.50	2881±2	20.5±0.1	18±2		
7	EX-7088	7.5	18.00	2665	16.1	18	0	150
8	"	4.7	20.00	2852	19.2	17	"	"
9	"	2.5	21.60	2995	22.8	16	10	"
10	"	"	"	2999	23.3	17	Tr	"
11	"	"	"	2979	20.9	20	10	"
Mean of 3 rounds			21.60	2991±8	22.3±1.0	18±2		
12	EX-7088	7.5	18.00	2663	16.2	18	0	150
Mean of rounds 7 and 12			18.00	2664±1	16.2±0.1	18±0		
13	EX-7087	6.4	17.50	2729	18.3	18	0	150
14	"	3.4	19.50	2925	21.6	"	"	"
15	"	2.5	20.10	2982	21.9	16	"	"
16	"	"	"	2993	23.2	18	"	"
17	"	"	"	2984	22.7	16	25	"
Mean of 3 rounds			20.10	2986±4	22.6±0.5	17±1		

CONFIDENTIAL
SECURITY INFORMATION

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 21 May 1953 (Continued)

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (ft/s)	Pressure (t.s.i.)	Ejec. Time (millisec)	Flash (%)	Smoke (%)
18	EX-7087	6.4	17.50	2734	18.1	18	0	150
	Mean of rounds 13 and 18		17.50	2732±3	18.2±0.1	18±0		
19	EX-7084	6.6	18.00	2731	19.2	18	0	150
20	"	3.6	20.00	2902	22.2	16	"	"
21	"	2.5	20.80	2975	23.3	19	10	"
22	"	"	"	2973	23.1	16	0	"
23	"	"	"	2998	26.4	"	25	"
24	"	"	"	2970	24.0	20	0	"
	Mean of 4 rounds		20.80	2979±10	24.2±1.1	18±2		
	Mean of rounds 21, 22 and 24		20.80	2073±2	23.5±0.4	18±2		
25	EX-7084	6.6	18.00	2721	18.3	18	0	150
	Mean of rounds 19 and 25		18.00	2726±5	18.8±0.5	18±0		

CONFIDENTIAL
SECURITY INFORMATION

CONFIDENTIAL

NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 26 May 1953

Gun: Mk 18-O, No. 16077

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (millisec)	Flash (%)	Smoke (%)
1 (a)	EX-7084	2.5	21.03	3006	26.1	16	0	150
2	"	"	"	2999	24.9	17	"	"
3	"	"	"	3010	25.6	15	Tr	"
	Mean of 2 rounds		21.03	3005±6	25.3±0.4	16±1		
4	EX-7087	2.5	20.24	2987	23.3	15	0	150
5	"	"	"	2995	22.9	19	"	"
	Mean of 2 rounds		20.24	2991±4	23.1±0.2	17±2		
6	EX-7088	2.5	21.70	3002	22.1	19	50	100
7	EX-7085	2.5	21.82	3011	24.3	18	0	150
8	EX-6822	2.5	20.60	2997	20.6	"	100	100
9	"	"	"	2998	20.9	19	"	"
	Mean of 2 rounds		20.60	2998±1	20.8±0.2	19±0		
10	EX-6883	2.5	20.42	2991	20.4	19	75	125
11	"	"	"	3001	20.8	19	"	"
	Mean of 2 rounds		20.42	2996±5	20.6±0.2	19±0		

(a) Conditioning round - not used

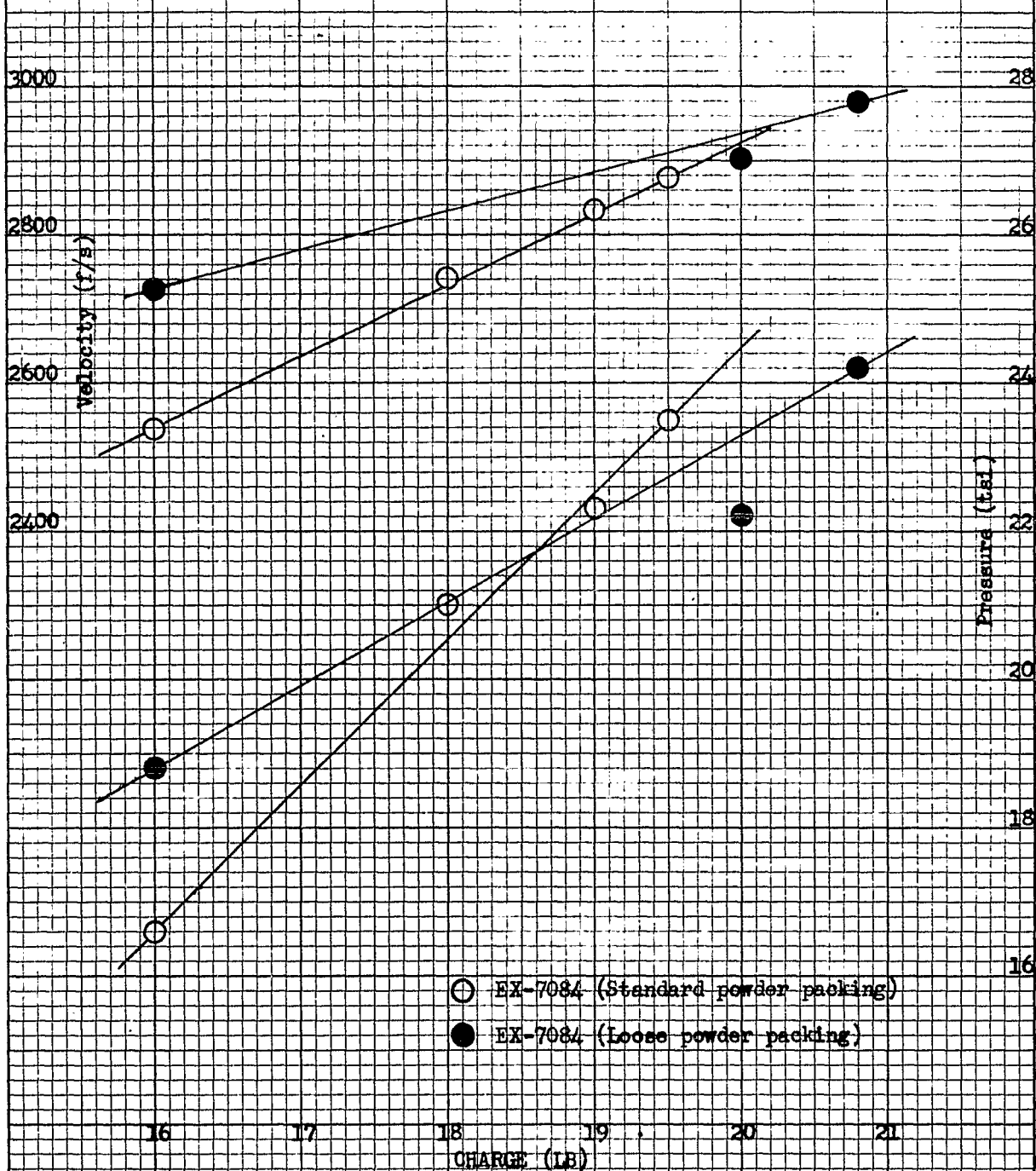
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SECURITY INFORMATION

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NPG REPORT NO. 1194

Ballistic Test of Cool Propellants

VELOCITY AND PRESSURE VS CHARGE



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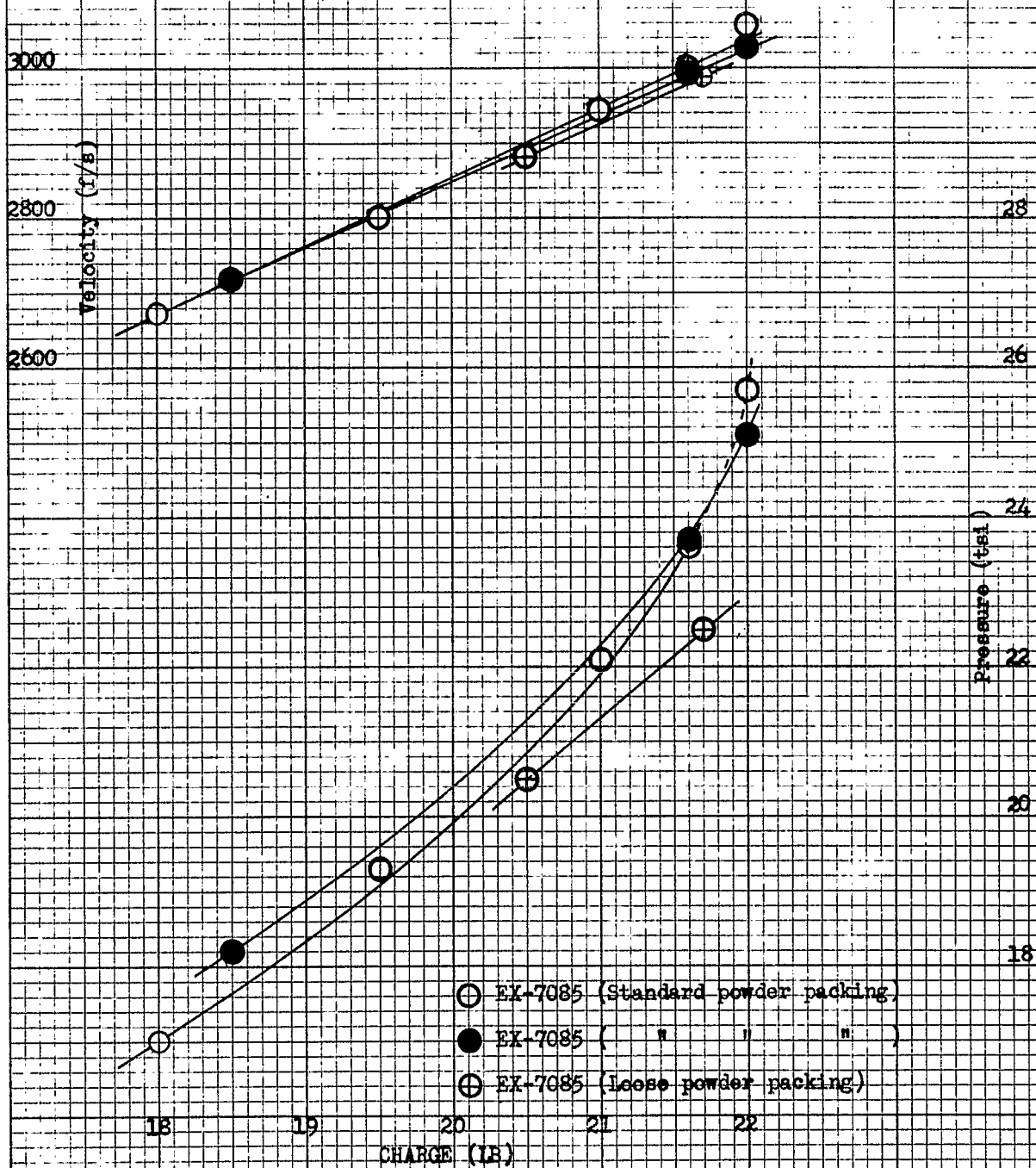
APPENDIX B

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NPG REPORT NO 1194

Ballistic Test of Cool Propellants

VELOCITY AND PRESSURE VS CHARGE



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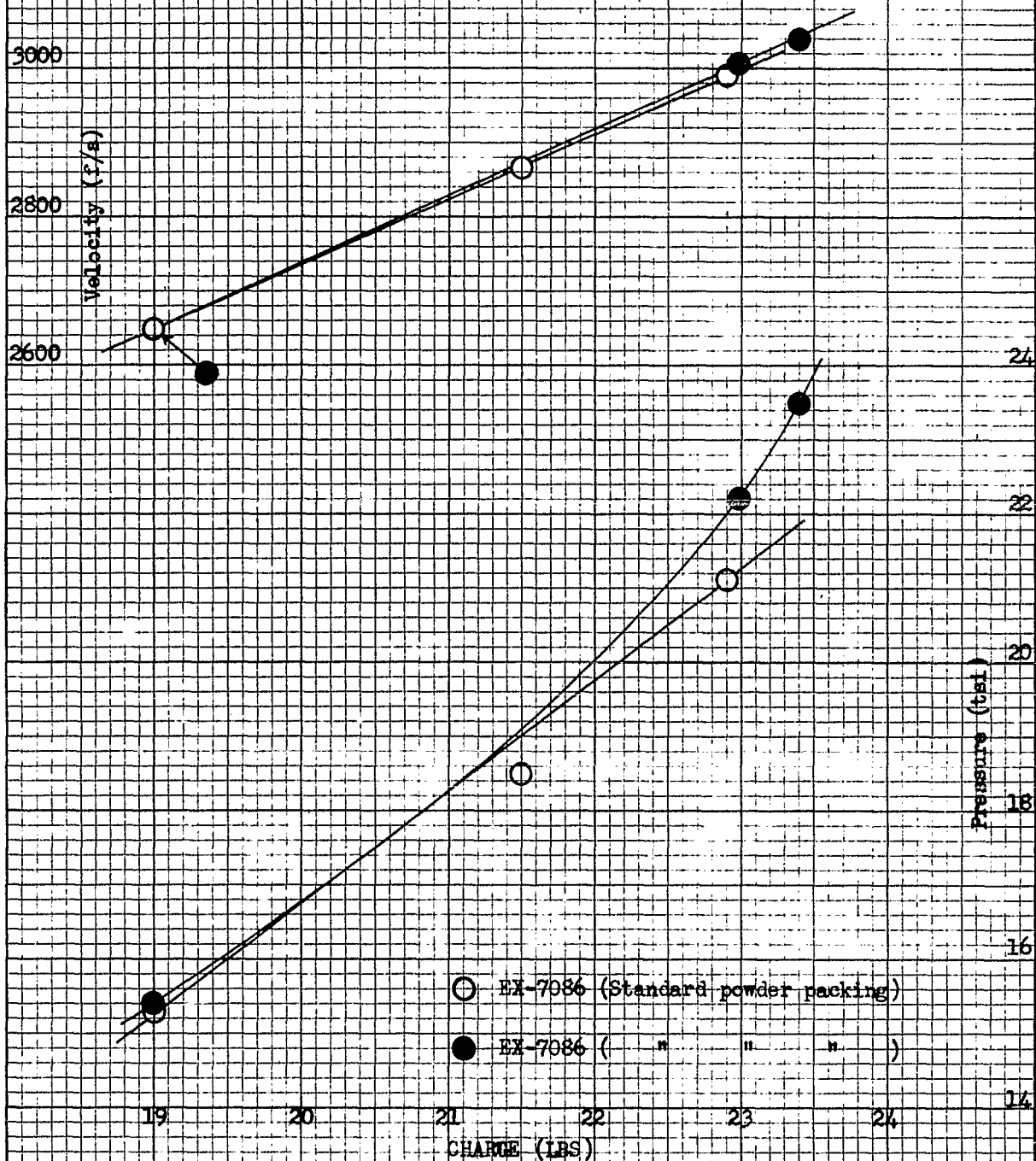
APPENDIX B

CONFIDENTIAL

NPG REPORT NO 1194

Ballistic Test of Cool Propellants

VELOCITY AND PRESSURE VS CHARGE



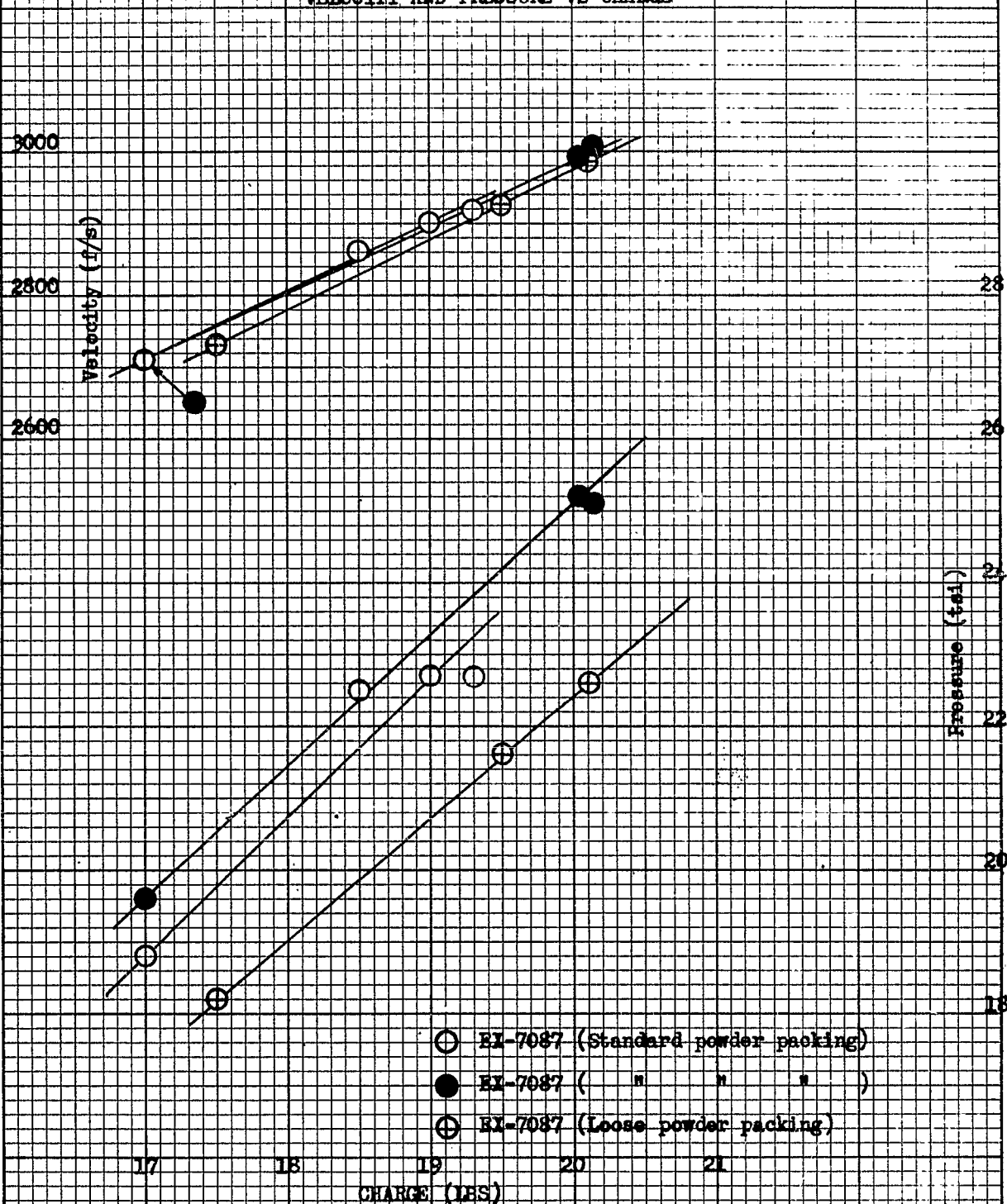
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NPG REPORT NO 1194

Ballistic Test of Cool Propellants

VELOCITY AND PRESSURE VS CHARGE



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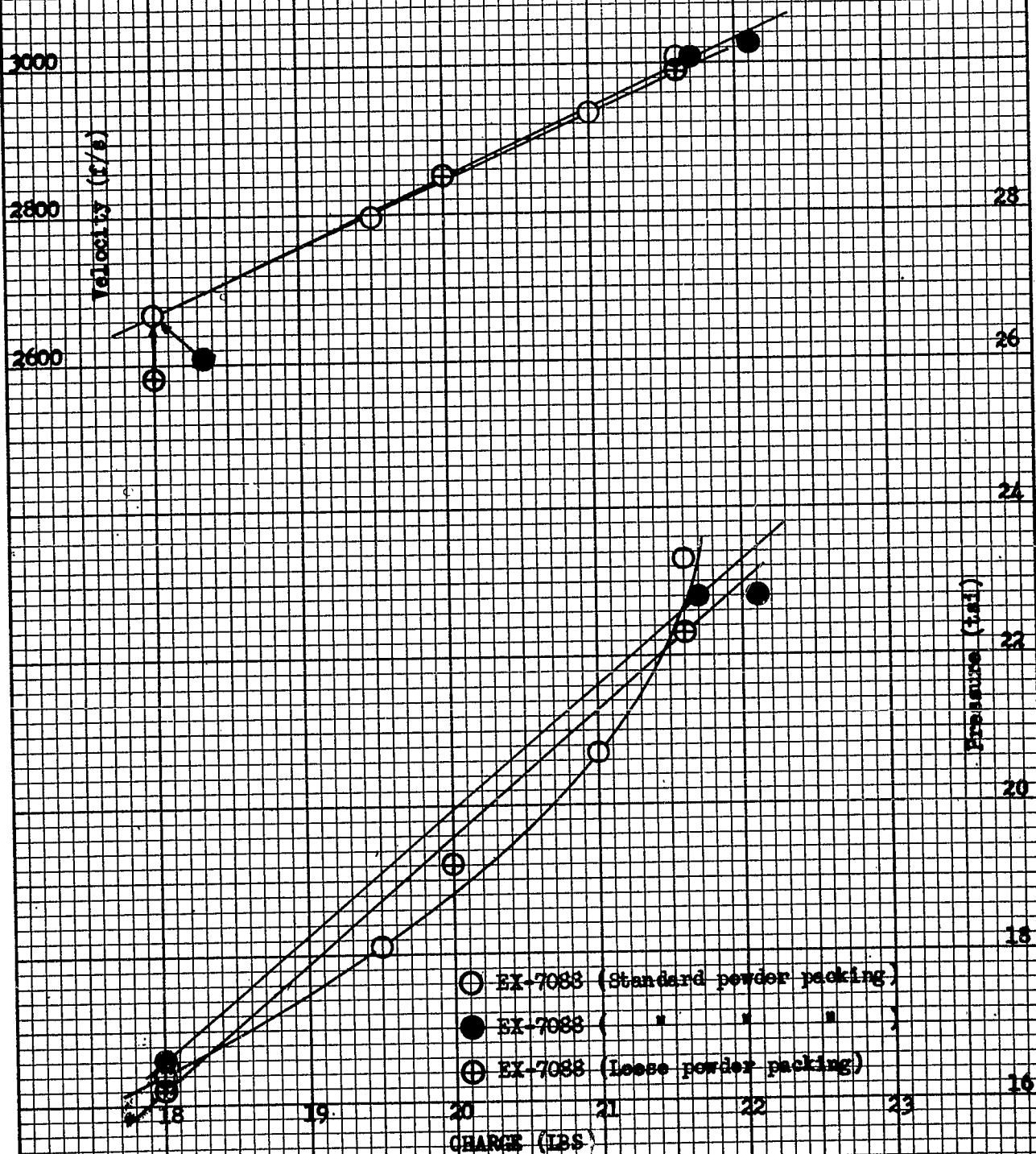
APPENDIX B

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NPG REPORT NO 1194

Ballistic Test of Coal Propellants

VELOCITY AND PRESSURE VS CHARGE



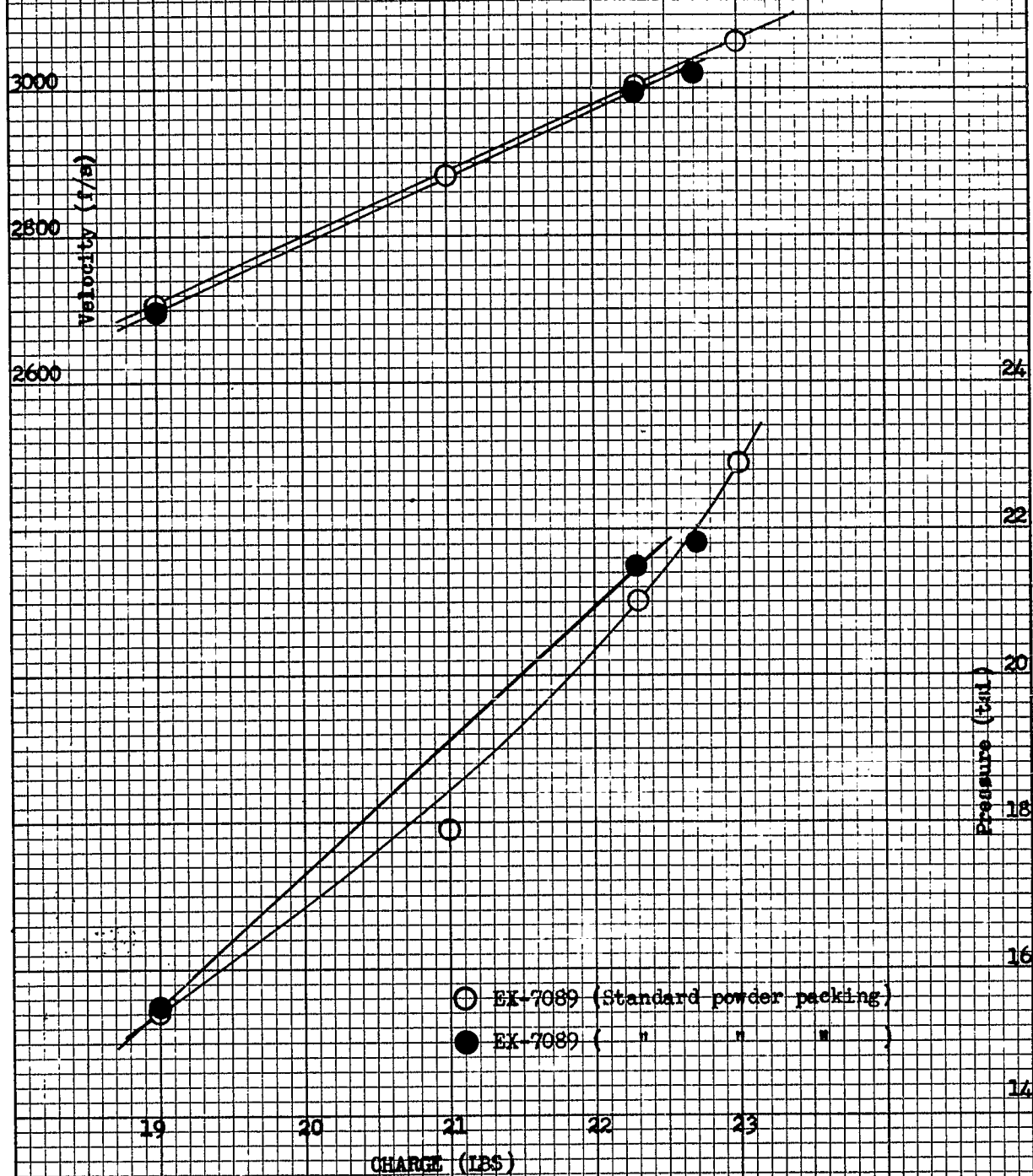
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NPG REPORT NO 1194

Ballistic Test of Cool Propellants

VELOCITY AND PRESSURE VS CHARGE



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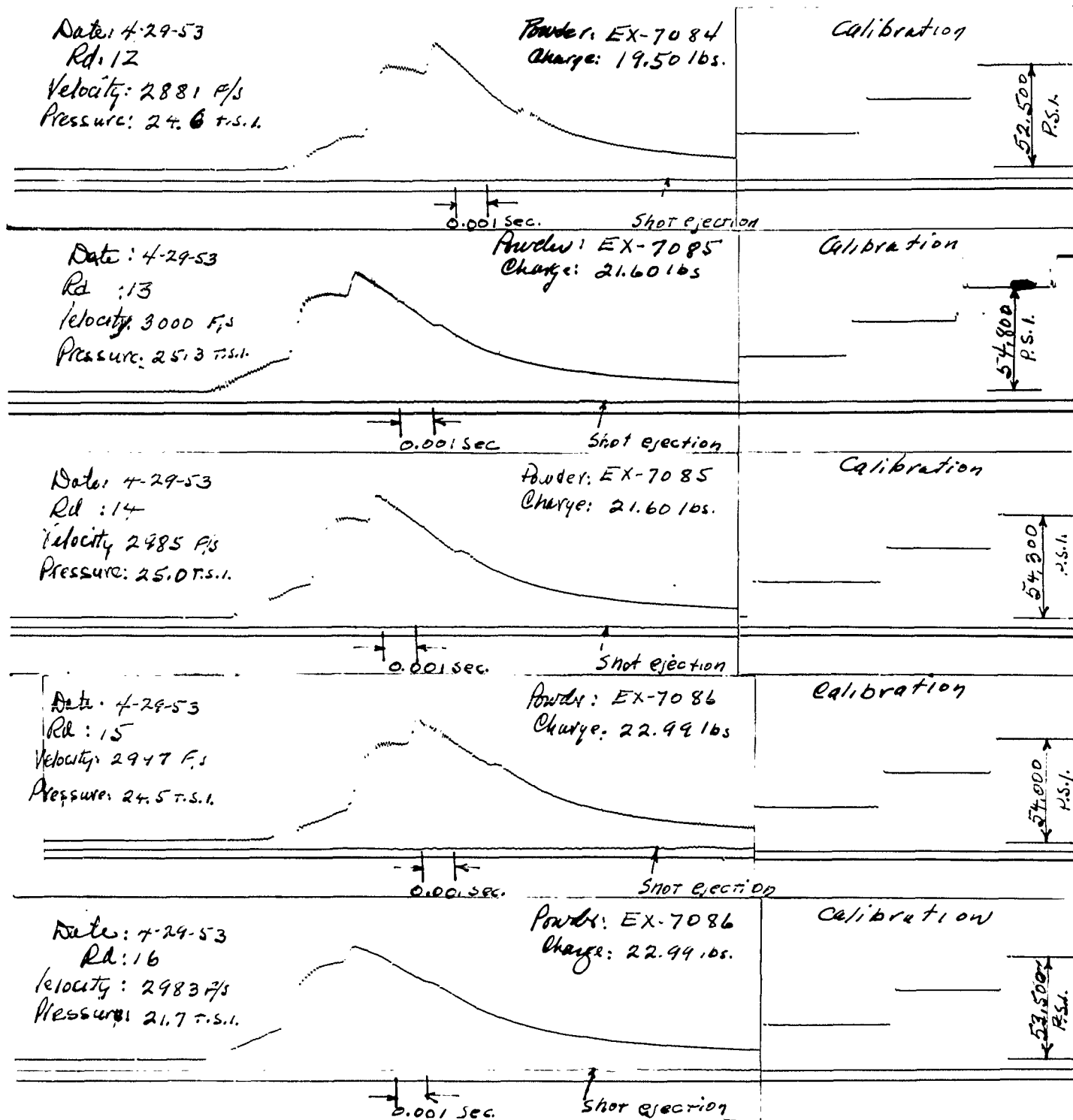
APPENDIX B

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NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 Inclusive

PRESSURE-TIME CURVES



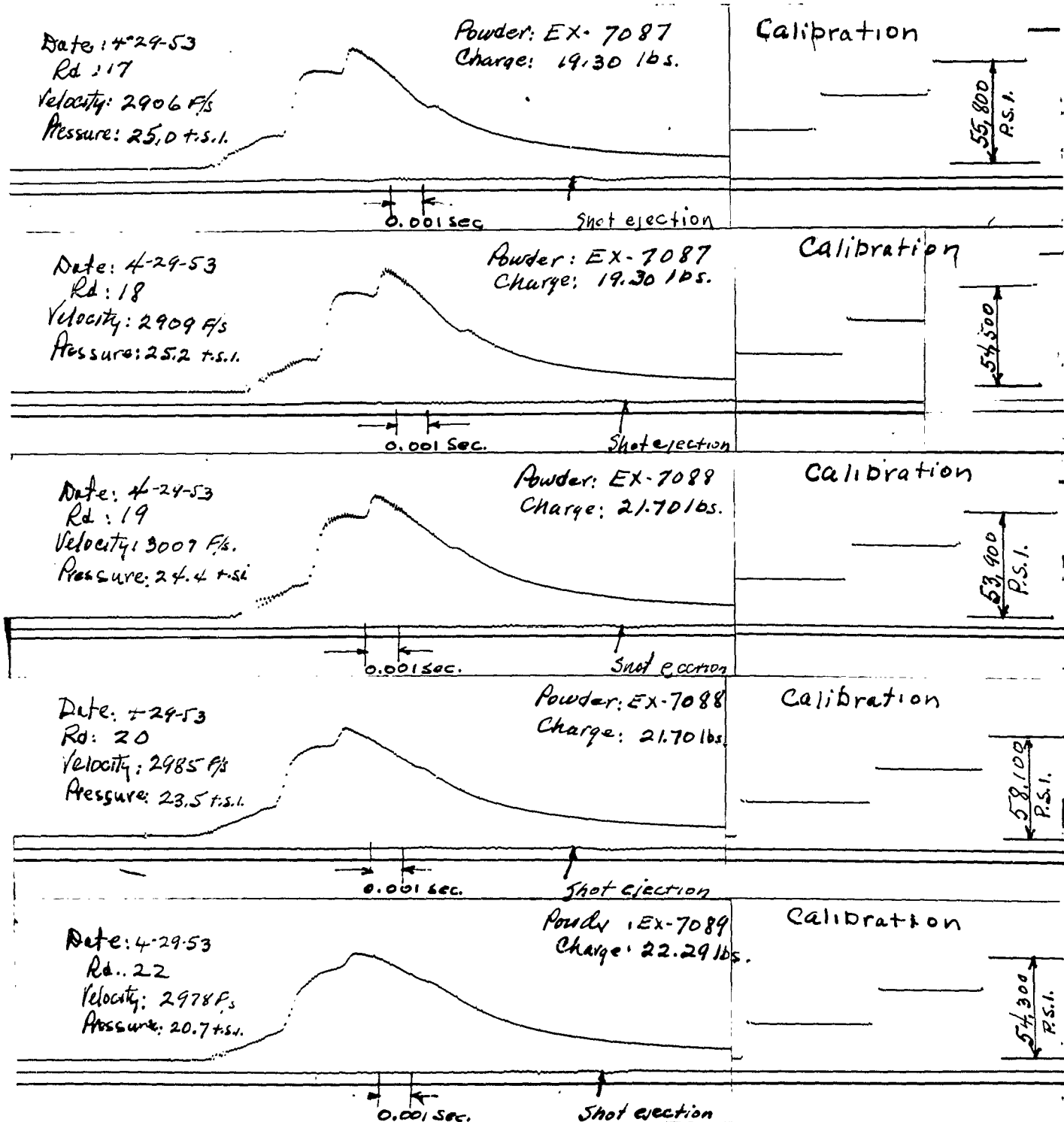
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NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 Inclusive

PRESSURE-TIME CURVES



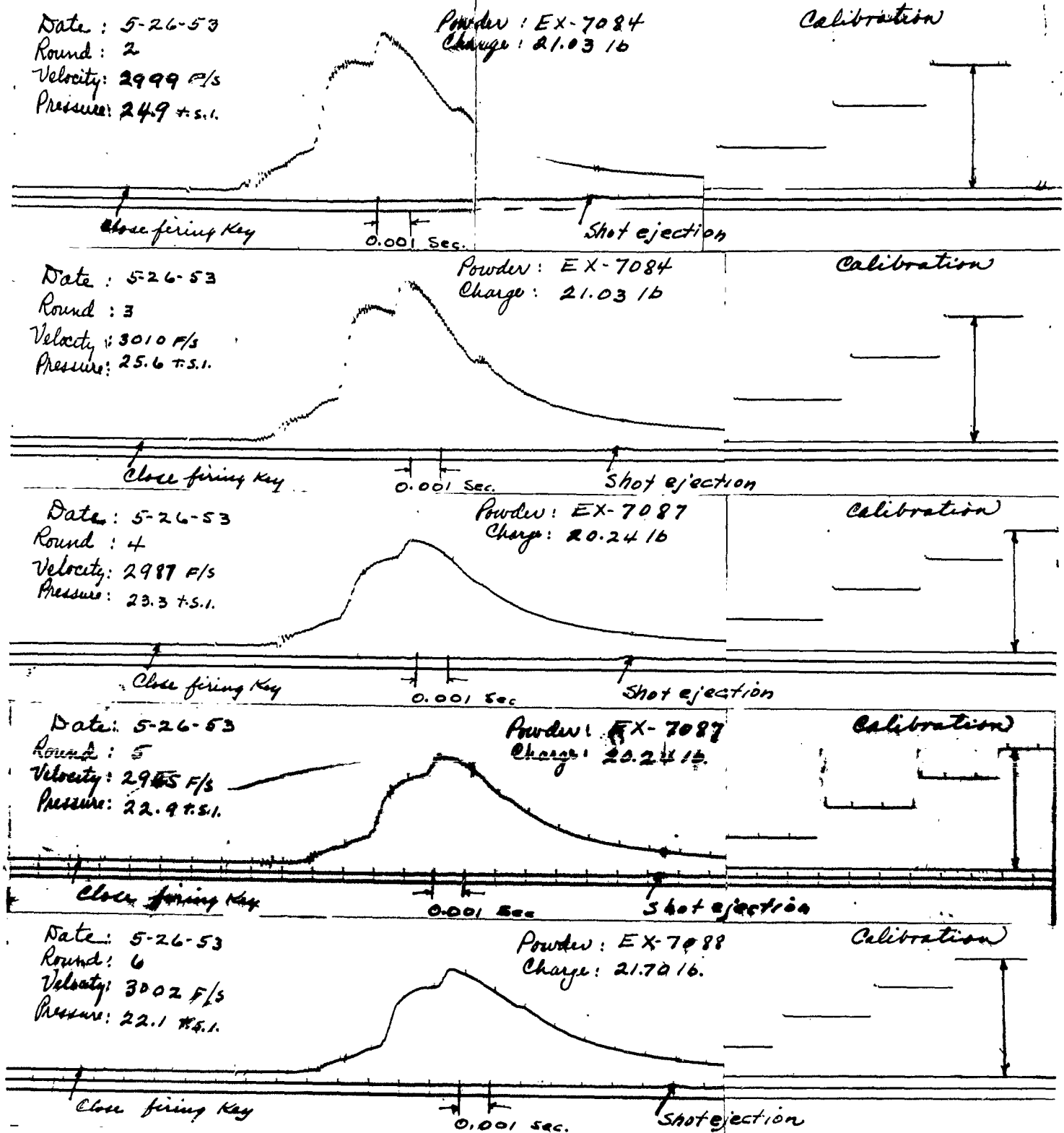
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NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 Inclusive

PRESSURE-TIME CURVES



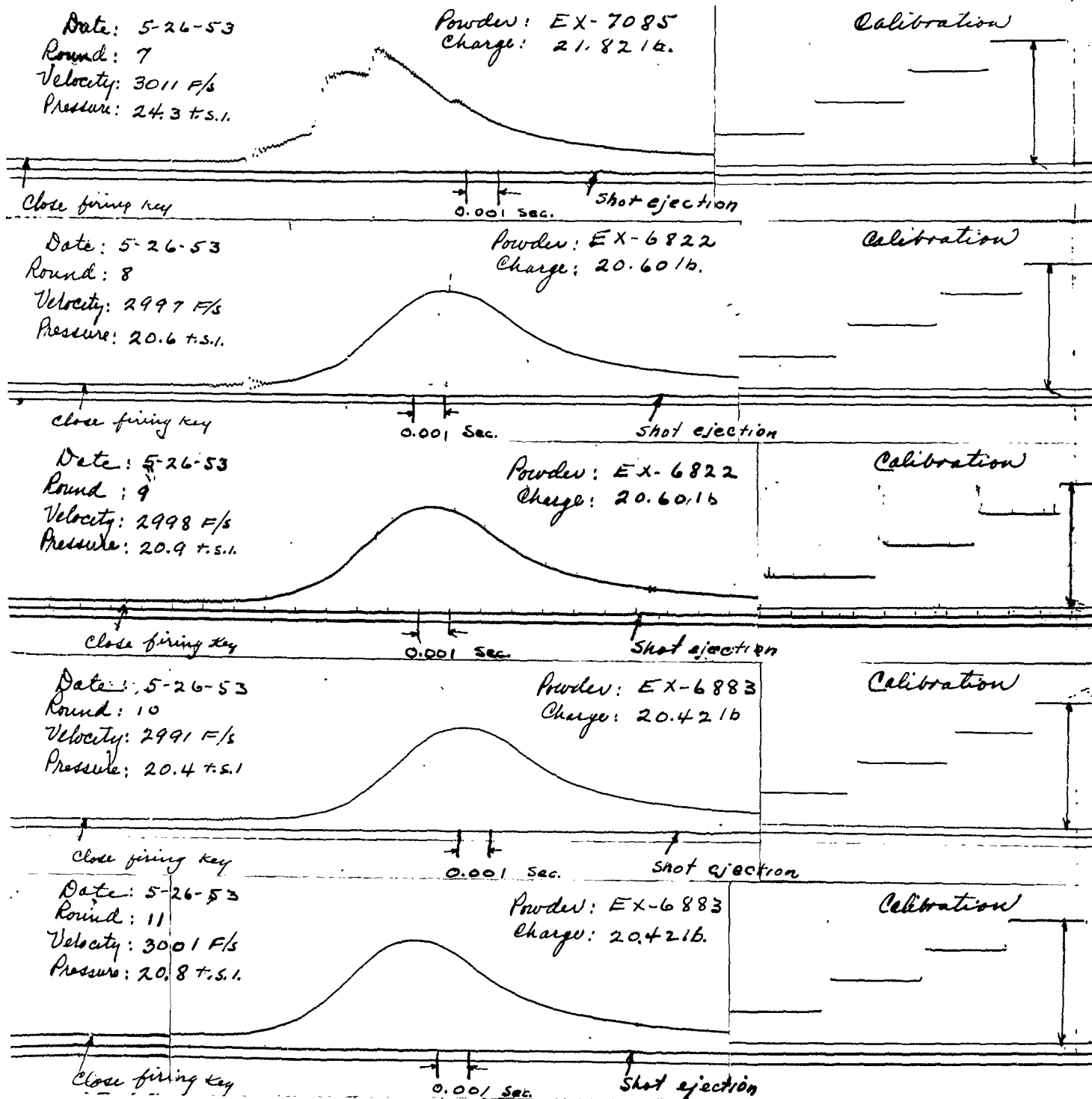
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NPG REPORT NO. 1194

Ballistic Test of Cool Propellants EX-7084 to EX-7089 Inclusive

PRESSURE-TIME CURVES



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SECURITY INFORMATION